THE

CAUSE OF RUSTINESS

AND OF

SOME OF THE LOSSES IN WORKING GOLD.

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THERE has always been a theory among those working placer mines that gold is both found "rusty," and becomes so under treatment, by which they mean, not that gold becomes coated with oxide of gold, but that it is either coated superficially or alloyed with some substance which prevents the contact with mercury, and thus precludes the possibility of amalgamation. To such conditions of the gold are ascribed the losses in working most placer deposits. Rusty gold is often talked about, but is not often shown, and when produced oftener amalgamates than not. It is frequently covered with a brownish coating, and has a much redder color than ordinary gold. The coating is very irregularly distributed over the surface, every spot where the least abrasion has occurred showing the true gold-yellow. All such spots form contact surfaces, and cause the whole piece to amalgamate readily. When the gold is wholly coated it resists the action of the mercury for a considerable time and perhaps altogether. This coating on gold is due to the superficial action of some substance, which is soluble and is often precipitated at the same time and by the same causes as the gold, for fine particles of gold are sometimes visible with the microscope in the detached coating. This coating has never to my knowledge been carefully analyzed. Those who describe it say that it often cracks off from pieces of gold leaving them bright. Nuggets of some size are said to have been found in South America, in alluvial soil, coated with a silicate of iron containing considerable gold. Very often the film is entirely composed of silica, which is deposited on and beside the gold. This silica is sometimes opaque, and again quite transparent, so that the gold can be seen disseminated through it with the microscope, just as cinnabar crystals are seen in the red chalcedony of the district around Knoxville, Cal. When the silica surrounds the gold entirely it prevents the gold from being attacked by the mercury, just as the fine particles of gold from the veins are carried off in the rock when it has not been rendered sufficiently fine in the crushing.

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While there are many artificial causes which produce the rustiness of gold, this covering of the surface with particles of some foreign substance is probably the only one which occurs in nature. In the separation of gold from its ore there are a number of causes which render it rusty or prevent its amalgamation in the mill. Some of these causes I have recently had occasion to investigate, and are, I believe, now announced for the first time; others have been more or less known for a number of years.

It has been asserted that the presence of certain substances alloyed with the gold would prevent its amalgamation. This I have generally found not to be the case. I have made a number of these alloys and have found them to amalgamate without difficulty, but chemical combinations frequently do resist the action of the mercury altogether, or when they yield, it is attended with the formation of a chemical compound with the mercury, and the consequent loss of the latter.

In order to ascertain the causes which prevent the amalgamation of gold I undertook to reproduce artificially the conditions which were supposed to prevent it. These I found to be mechanical and chemical. I found that if a piece of soft gold which could be easily bent, and amalgamated readily, was hammered on a perfectly bright anvil, with a bright hammer, giving several rapid blows, until the gold had become hard, and had acquired a certain amount of elasticity, it would remain in juxtaposition with mercury for a very long time without being affected by it. This hammering increases the density of the metal and closes the pores, so that I have recently had a piece of gold which was put into this condition by hammering, remain nearly two weeks floating on mercury without being attacked. If the gold in this condition is heated and cooled slowly, it again amalgamates rapidly. If, however, it is cooled rapidly by plunging it suddenly into very cold water the amalgamation takes place very slowly. The same metal, after being repeatedly rapidly cooled and heated, amalgamates more readily than if it has only been treated once.

To ascertain the effect of different substances on the gold, a strip of clean gold which readily amalgamated was dipped into a solution of sulph-hydrate of ammonia, and also into one of sulphuretted hydrogen. After being withdrawn from these liquors and allowed to dry, mercury would not touch either of the pieces. The effects of grease are well known, and the greatest care is taken in most mills to keep the "quick" bright, either by rubbing or by the

addition of chemicals, to such a extent in some cases that the chemicals themselves used in excess are often a cause of the very thing they are intended to prevent. All these causes, the hammering, the effect of sulphuretted waters, and also the effect of grease, occur in every mill, and probably have something to do with the losses in gold which take place there.

The effect of the different elements likely to be found with gold was also investigated. A strip of gold which would amalgamate easily was exposed to vapors of sulphur, after which it would not amalgamate. When the piece was heated in the flame of a Bunsen burner, the film of sulphide was decomposed, and the gold amalgamated readily. To test the effects of arsenic and antimony upon gold, these metals, in variable proportions, were melted with it, and it was ascertained that considerable quantities of arsenic and antimony were in the alloys. Both these alloys amalgamate very easily. Gold and arsenic and gold and antimony were then precipitated together, and it was found that the precipitates were compounds of antimony and gold and of arsenic and gold; they also amalgamated readily. It has been asserted that .0004 gram of antimony to the ton of auriferous pyrites of Grass Valley, and .001 gram in that of Callao, was sufficient to prevent the amalgamation of the gold.* This seems, however, to be not quite exact, if the statement given of the conditions in which the gold is found be correct, for there does not seem to be any reason why an alloy with a much larger amount, as in the artificial compounds, should amalgamate readily, and the natural one containing so much less, refuse to do so.

The effect of sulphur was further studied by making a regular sulphide of gold. When this was heated it was found that the sulphur was readily driven off by ignition, and the residne, which was bright-yellow gold of exactly the same shape as the sulphide, easily amalgamated. A phosphide of gold was then made by pouring melted phosphorus upon hot sponge-gold, and expelling the excess of phosphorus by heating for some time in a non-oxidizing atmosphere. It did not amalgamate. Oxide of gold was made, but this compound is so very unstable and so readily reduced to metallic gold by simple rubbing that it could not possibly have any effect on preventing amalgamation, although it is not attacked by mercury. An amalgam of gold was then placed in acid, which easily dissolved out the mercury, and left behind a brown crystalline residue of gold, which readily took up mercury again.

* Comptes Rendus, March 17th, 1879.

It will thus be seen that the stamp-mill is not a rationally designed machine. The action of pounding is likely to put some of the gold into such a condition that the mercury will not touch it, and to flour the gold, as well as the quicksilver. There is, besides, in the mill every probability of the introduction of grease or greasy substances, like the powdered hydrated silicates of magnesia and of alumina, which not only froth but coat the gold with a slime which prevents the action of the mercury. If the water used in the mill is not pure, there is a further likelihood of the introduction of sulphuretted hydrogen, and of other soluble sulphides, which act superficially on the small particles of gold, and prevent the action of the mercury. I have elsewhere pointed out some of the other causes of losses in the treatment of gold.* The pounding action of the stamp has doubtless the effect to make some of the particles of gold wholly unattackable by mercury, while the action of rubbing that occurs in the arastra is much more likely to pulverize the fine particles of pyrites, to break up any coating that may be around the particles of gold, and to rub off any superficial deposit, and thus bring the gold into contact with the mercury and make it amalgamate. It would be folly to advocate the reintroduction of the arastra which is so limited in its output, but I am satisfied that we shall have to come back to its principle. It is a very remarkable fact that when in the early days Mexicans with the arastra got $50 to $60 a day, the stamp-mill working on the same rock obtained only $15 to $20, and instances are cited where with the best modern machinery only $20 to $30 can be got out of rock which yields $700 to $800 by the fire assay. One or two machines have recently been constructed on the arastra principle, but no systematic tests have been made of them and little done beyond the singing of their praises by enthusiastic inventors.

* On the Formation of Gold Nuggets and Placer Deposits. A paper read at the Philadelphia Meeting, February, 1881.